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A REVIEW OF RECENT RESEARCH ON THE PERCIDS,PERCH *PERCA FLUVIATILIS* L. AND RUFFE *GYMNOCEPHALUS CERNUUS* (L.), IN SCOTLAND

JAMES W. TREASURER

Marine Harvest McConnell, Lochailort, Inverness-shire PH38 4LZ

INTRODUCTION

The perch, *Perca fluviatilis* L., was the only percid species found in Scottish freshwaters prior to 1982 (Maitland & Campbell, 1992). As salmonids are the main commercial and sport fishes in Scotland and have also dominated the aquaculture industry, perch fisheries have little economic value, unlike in England, and have consequently remained largely unexploited and unmanaged. Another major feature of perch stocks in Scotland is their occurrence in simple fish communities. The likely reason for this is that, following the last glaciation approximately 10,000 years ago, fishes colonised the British Isles northwards from the southern tip of England (Maitland, 1977). Expansion to Scotland was slow and by 1790 only 15 freshwater species had been recorded. Although there is little commercial interest in perch, the species is one of the commonest and most widely distributed fishes in lacustrine habitats in lowland Scotland (Maitland, 1972).The extent of competition with salmonids for food has not been quantified, but perch in Loch Leven (Thorpe, 1977a) and in Loch Tummel (Campbell, 1955) consumed food items that were also major prey items of brown trout *Salmo trutta* L., although only seasonally. Perch larvae have also a significant impact on zooplankton communities, cropping up to 29% of *Cyclops strenuus abyssorum* biomass per day and 27% of *Diaptomus gracilis* in two Deeside lochs (Treasurer, 1992).

Research on percids in Scotland has dealt with the age and growth of perch in Loch Lomond and Dubh Lochan (Shafi, 1969; Shafi & Maitland, 1971), the daily food consumption of perch in Loch Leven, Kinross (Thorpe, 1977a), reproduction of perch in two Deeside lochs (Treasurer, 1981; Treasurer & Holliday, 1981) and Loch Leven (Jones, 1982), production in the egg stages (Treasurer, 1983), growth (Treasurer, 1988) and food (Treasurer, 1990a) of larvae, and studies of population dynamics (Treasurer, Owen & Bowers, 1992). The recent introduction of a second percid, the ruffe *Gymnocephalus cernuus* (L.), to Loch Lomond and its impact on the rare population of powan *Coregonus larvaretus* L. and on the pike *Esox lucius* L. has been recorded (Maitland & East, 1989; Adams & Tippett, 1991).A synopsis of data on perch was provided by Thorpe (1977b). This paper reviews the findings on percid biology in Scotland since that publication. It is based largely on the author's own work and focuses on three types of faunal community: perch in a simple fish species system with no top piscivore; perch in a simple predator-prey relationship with pike; ruffe in a more complex fish association. Methods employed by the author are summarised elsewhere (e.g. Treasurer, Owen & Bowers, 1992).

STUDY AREAS

With regard to simple fish communities lacking a top piscivore, the author has examined perch in two small and shallow lochs in North east Scotland (Fig. 1). Sand Loch is only 300m from the sea and the only other fish species present is the three-spined stickleback *Gasterosteus aculeatus* L.. Angling is not permitted as the loch is part of the Sands of Forvie National Nature Reserve. The second loch, Lower Loch, is 18.5 km due west of Sand Loch and was constructed as a duck shooting water in the nineteenth century. The loch is enclosed by mixed coniferous and deciduous woodland and dense *Phragmites communis* beds make access possible only by boat. Eel *Anguilla anguilla* L., and three-spined sticklebacks are common and brown trout rare. The loch is unfished and the local estate was unaware of the presence of perch in the loch.

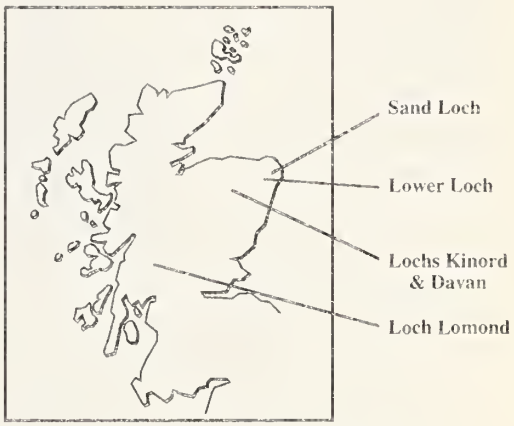


Figure 1. Locations of lochs mentioned in review

The author examined perch in a simple predator-prey association in Lochs Kinord and Davan in the Dee valley. Both are shallow (mean depth 1.5 m). Kinord has been classified as oligotrophic and Davan as slightly mesotrophic with some input of nitrate from agricultural land upstream of the main feeder stream. Eels and pike are common in both lochs. Both are part of the Muir of Dinnet National Nature Reserve and are rarely fished.

Perch and ruffe have also been studied in Loch Lomond (Maitland & East, 1989). This is the largest lake in the British Isles with an area of 71 km^2 and a mean depth of 37 m. It has the most diverse fish fauna in Scotland with 18 species recorded. It is in an area of Special Scientific Interest, is important recreationally, and has a coarse fishery.

Simple fish communities without a top piscivore

Growth of perch in Sand and Lower lochs is faster than in most other British waters (Table 1). Greater lengths at each age are only found in Cheshire lakes where fast growth is attributed to high food availability and low perch abundance (Goldspink & Goodwin, 1979), and also in the River Stour,

Table 1: Mean length-at-age of perch in Scottish lochs compared with other lakes and rivers in Britain

Lake/river	Length (mm) at age:															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Kinord, males	55	89	137	179	213	235	251	244	256	263	270	277	283	290	295	299
females[1]	54	88	142	188	223	248	266	274	283	283	287	290	295			
Davan, males	63	100	149	175												
females[1]	62	100	157	202	239	267	284	297	282	292	301	310	316	320	326	329
Sand, males	62	128	180													
females[2]	62	128	185	232	255											
Lower, males	82	157	198	232												
females[2]	79	157	206	242	267											
Lomond[3]	67	107	143	165	186	204	220	241	273	314	340	361	375			
Dubh Lochan[3]	51	76	94	108	120	131	143	152	164	172	181					
Windermere[4]	76	112	147	173	192	198	230									
Ullswater[5]	64	114	144	165	177	185	191	194	197	199						
Llyn Tegid, males	56	88	115	129	143	157	168	182	194	211						
females[6]	55	88	115	134	151	165	178	191	203	216						
Cheshire Meres[7]	94	155	214	272	308	331	346	358	367	382	390					
Slapton Ley[8]	75	122	155	189	220	242										
R. Stour males	74	152	205	250	273	295	310	326								
females[9]	75	164	226	269	296	314	319	330	338	346						
R. Thames[10]	69	92	111	122	137	155	169	187								
East Anglia[11]	58	86	111	147	165											

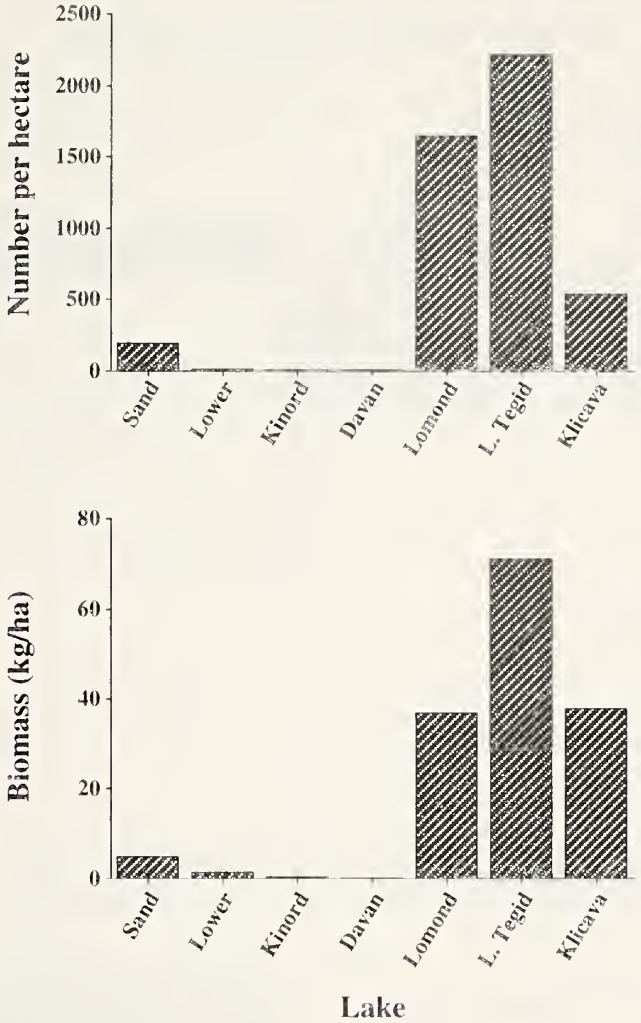
Authorities:1 = Treasurer, 1980; 2 = Treasurer, 1993; 3 = Shafi & Maitland, 1971; 4 = Le Cren, 1958; 5 = McCormack, 1965; 6 = Ali, 1973; 7 = Goldspink & Goodwin, 1979; 8 = Craig, 1974; 9 = Mann, 1978; 10 = Williams, 1967; 11 = Hartley, 1947

Table 2: Numbers and production (kg wet weight/annum) of perch populations

Lake/river	Age groups (years)	N/ha	P kg/ha
Kinord[1]	3 - 17	4.8 - 9.8	0.32 - 0.39
Davan[1]	3 - 17	6.6	0.2
Sand[2]	>2	207	5.4
Lower[2]	>2	16	1.1
Lomond[3]		1649 - 1695	34 - 39
Leven[4]		2 - 9	27.9
Windermere[5]		>2	30 - 492
Llyn Tegid[6]		2210	70.5
R. Thames[7]		2400	23
R. Nene[8]			7
Klicava[9]		210 - 880	14 - 62

Authorities: 1 = Treasurer, Owen & Bowers, 1992; 2 = Treasurer, 1993; 3 = Shafi, 1969; 4 = Thorpe, 1974; 5 = Le Cren *et al*, 1977; 6 = Ali, 1973; 7 = Williams, 1965; 8 = Hart, 1971; 9 = Oliva & Holcik, 1965

Figure 2 Numbers and production of adult perch > 3 years old, in Scottish lochs compared with Llyn Tegid and the Klicava reservoir. Data from L. Lomond (Shafi, 1969); Llyn Tegid (Ali, 1973); Kilcava (Oliva & Holcik, 1965).



Dorset (Mann, 1978) because of low density of perch and early piscivory by young perch on cyprinid juveniles. Treasurer (1993) concluded that high growth rates in perch in simple fish associations in North east Scotland were due to low biomass coupled with nutrient enrichment and availability of sticklebacks as prey. Numbers and production of adult perch were low in these lochs (Treasurer, 1993) compared with perch found in more diverse fish communities in Britain (Table 2). Treasurer (1993) concluded that, in the absence of a top piscivore, the abundance of perch is suppressed by cannibalism by adults as cannibalism has been shown to be a key regulatory mechanism in perch (Menshutin & Zhakov, 1964).

Perch and pike in a simple-predator prey association

Treasurer (1983) estimated the numbers of adult perch as 4.8 - 9.7 ha^{-1} in Loch Kinord and 5.5 ha^{-1} in Loch Davan and production as 0.32 - 0.39 and 0.20 kg ha yr^{-1} respectively, similar to Sand and Lower lochs (Fig. 2). Growth rates were high for highland lochs (e.g. Table 1), possibly as a result of low numbers. All age classes were were represented in samples with little fluctuation in year class strength (Fig. 3). This can be compared to many perch populations which are dominated by strong year classes and which can be subject to wide variations in year class strength, up to 300-400 times, as found in perch in the Lake District (Kipling, 1976).

The extent of losses of 0+ perch to cannibalism and predation by pike was assessed by the author from the decline in numbers of larvae in a high speed plankton sampler and in a seine net in the juvenile period (Treasurer, 1989). Perch larvae were present in the diet of perch from 1 June and contributed a large proportion (59-63%) of the diet through the larval period (Fig. 4). Larvae were not found in the stomachs of pike but perch were taken on transition to the juvenile period c. 16 June. There was no indication of cannibalism in 0+ perch. Juvenile perch were important in the diet of perch and pike, contributing up to 80% occurrence of food items in adult perch and 90% in pike. The estimated decline in numbers of 0+ perch was compared with the estimate of larvae consumed by adult perch and pike on two dates and for juveniles on 3 occasions (Fig. 5). Comparison of the modelled values with the decline in numbers of 0+ perch indicates that cannibalism at Loch Kinord would have been responsible for a large proportion of the mortality of larvae. On transition to the demersal period on 16 July about 50% of perch mortality was attributed to predation divided almost evenly between perch and pike, with lower but significant losses on later

Figure 3. Age distribution of perch in simple fish communities, Sand Loch and Lower Loch and in Lochs Kinord and Davan with a simple predator-prey association of pike and perch

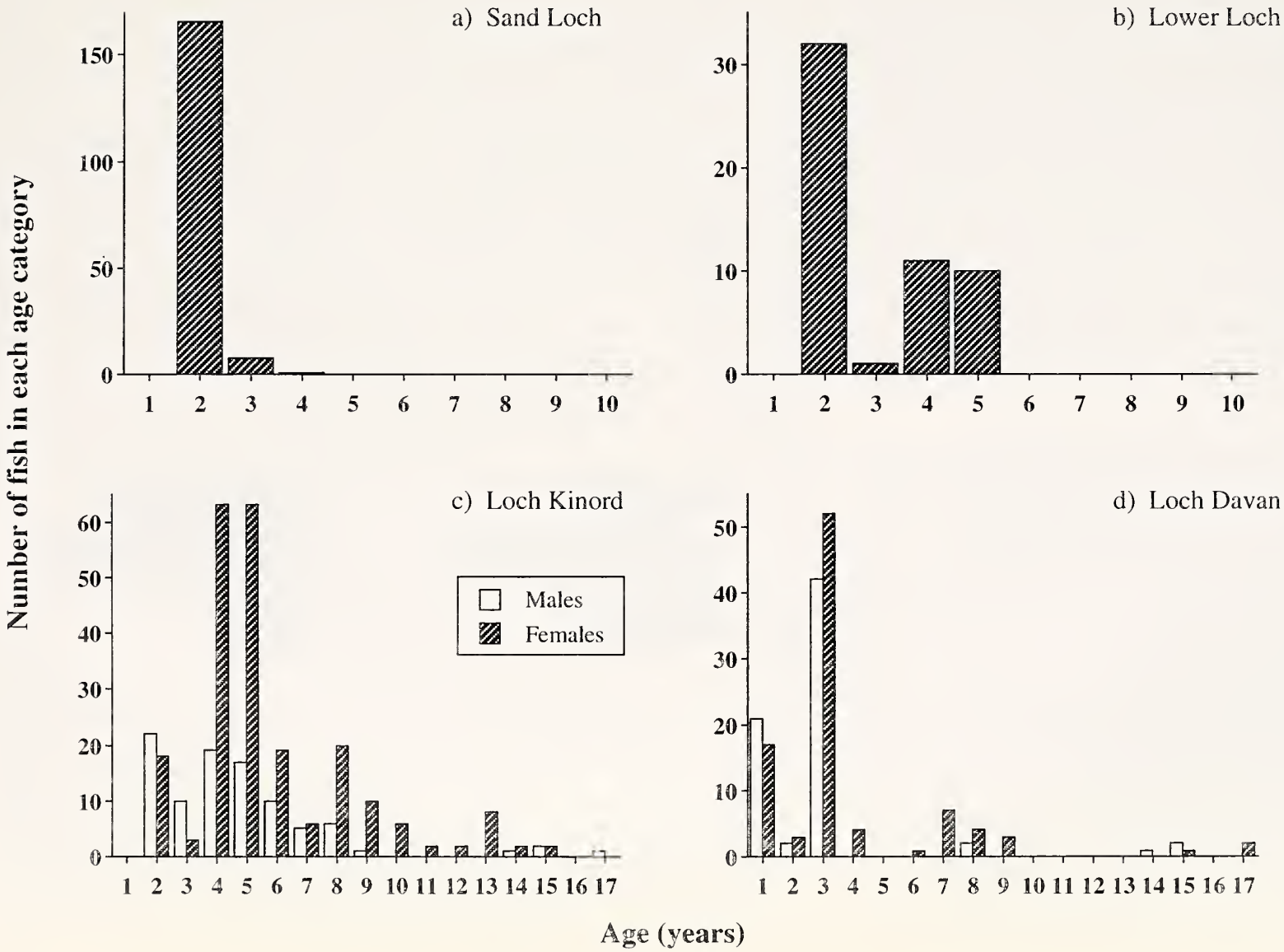
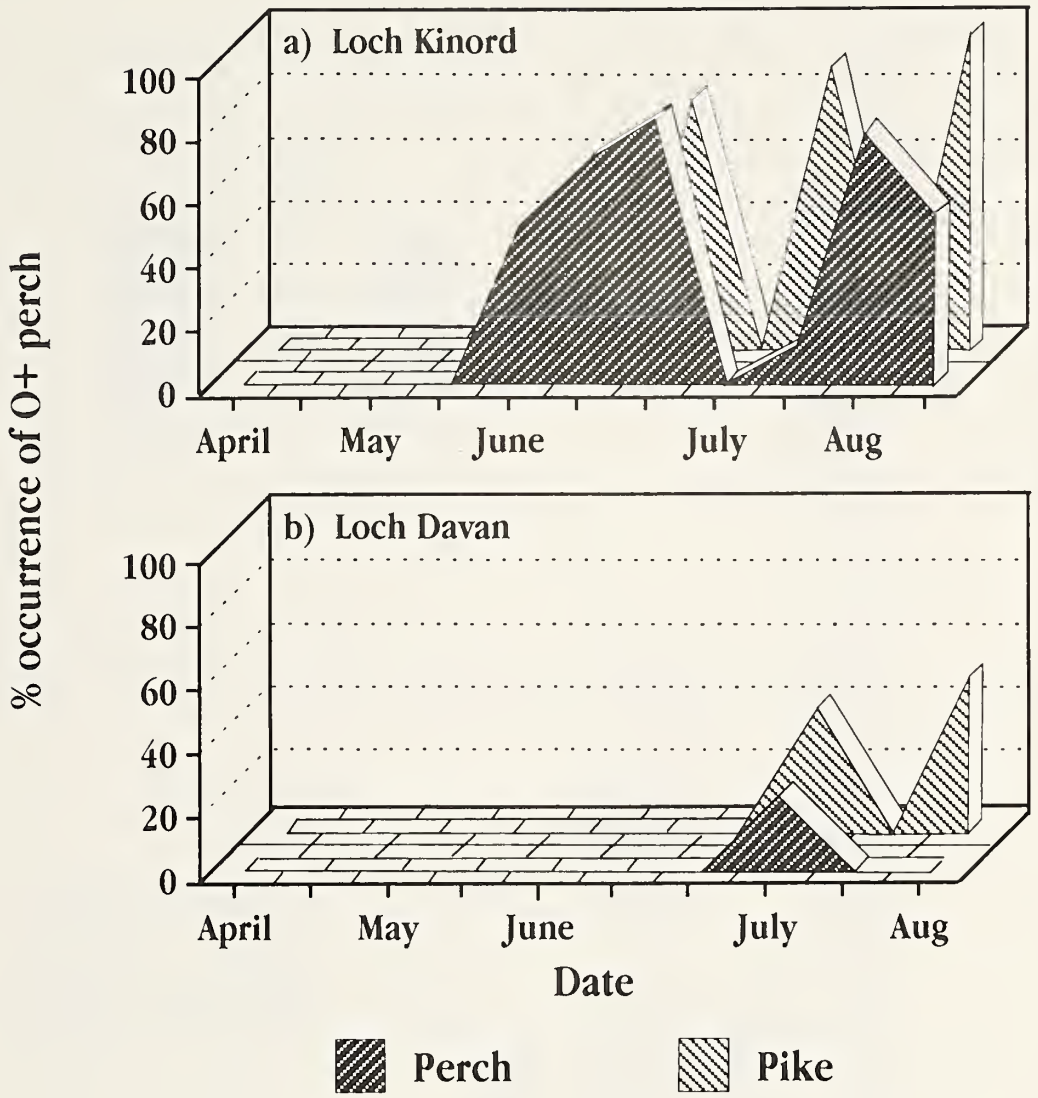


Figure 4 Percentage occurrence of 0+ perch in the diet of adult perch and pike in Lochs Kinord and Davan



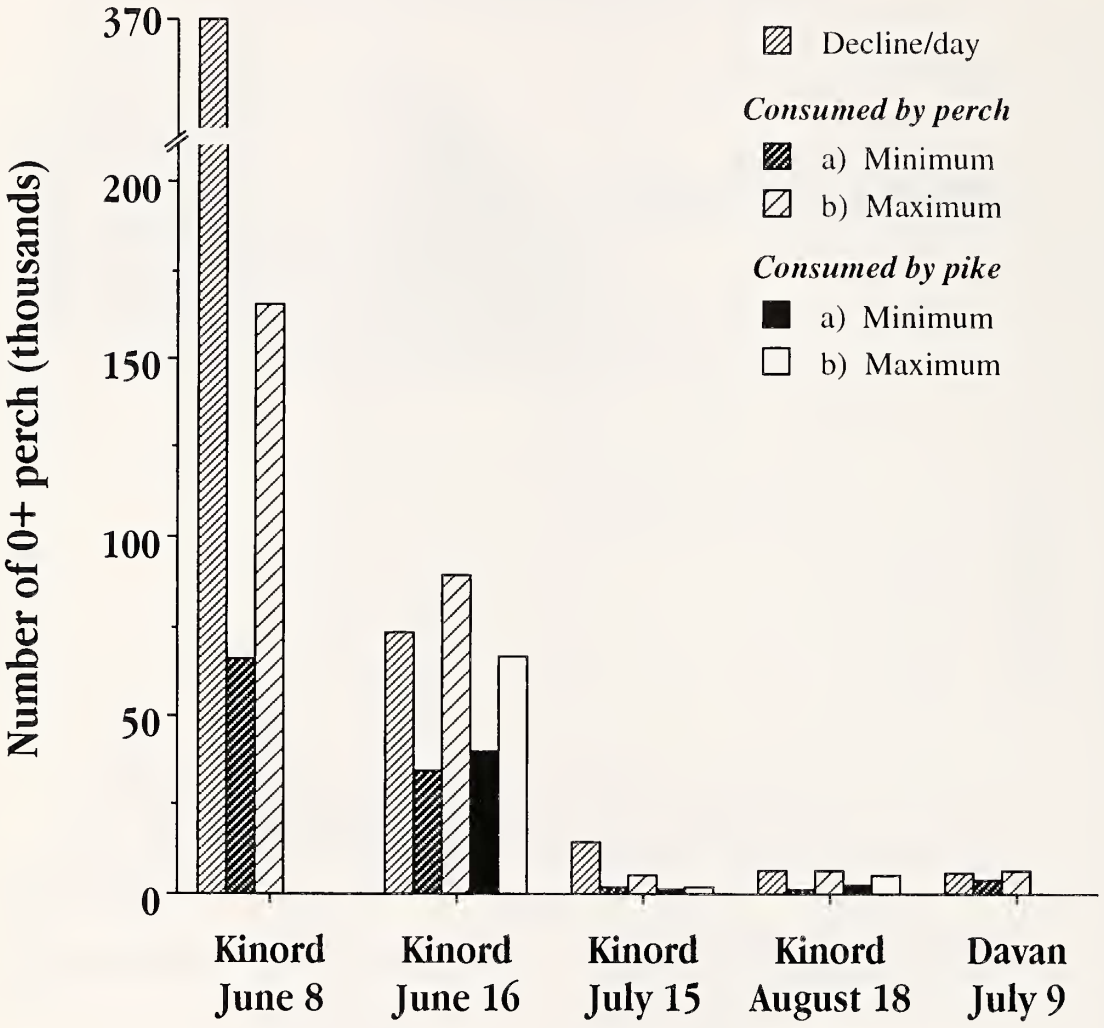
dates. At Loch Davan cannibalism accounted for all mortality of perch juveniles and predation by pike was less important (Treasurer, 1989).

Numbers and production of perch were lower than in many lakes in Britain and elsewhere (Table 2) although density and production of pike were similar to other European waters (Treasurer, Owen & Bowers, 1992). High predation pressure by pike on 1+ and 2+ perch as well as juveniles can be gauged from the ratio of numbers and biomass of pike to perch (Fig. 6). This is lower than the ratio of perch to pike in Windermere from 1941 to 1966 in the range of 8 to 44 which Le Cren et al. (1977) considered to indicate intense predation pressure. Therefore, the unusually low numbers and production of perch in the simple pike-perch associations in the Deeside lochs is due to a combination of intense predation by pike together with cannibalism.

More complex fish communities

The growth rate of the perch in Loch Lomond has been shown to be fast for European waters (Table 1). Although the loch is too large to obtain a population estimate by conventional means such as mark-recapture techniques (Shafi, 1969), the relative composition of fish species has been recorded from screens on pumped water from a water supply system. Perch dominated the catch in 1983, representing 69% of fish captured (Maitland, East & Morris, 1983; Maitland & East, 1989) when the ruffe was recorded in Scotland for the first time, probably having been introduced as livebait by anglers. The proportion of ruffe in the pumped water screens increased to 92% of catch by 1987 (Maitland & East, 1989) (Fig. 7). Concern has been expressed regarding the impact on native species such as the unique population of powan (Adams & Tippett, 1991). Powan eggs are important in the

Figure 5. Actual decline in numbers of 0+ perch at Lochs Kinord and Davan compared with estimated consumption by adult pike and perch



diet of ruffe (representing 84% by weight) and ruffe maintain a higher winter feeding rate than other predators of powan eggs, including powan themselves and brown trout. Similarily, ruffe numbers have increased dramatically in Lake Constance since they were introduced in 1987. They feed mainly on coregonid eggs during December and are thought to affect coregonid abundance (Rosch & Schmid, 1997). Introduced ruffe have rapidly colonised Bassenthwaite Lake in England and Llyn Tegid in Wales where nationally rare Coregonus species are also present (Winfield, Adams & Fletcher, 1997). The ruffe has recently colonised lakes in North America, having been accidentally introduced from Europe in 1986 in the ballast water of ships, with potential impact on native species (Savino & Kolar, 1996). This widespread expansion in the range of ruffe merits close scrutiny of possible further introductions in Scotland.

CONCLUSIONS

In the relatively simple fish communities in Scotland examined in recent investigations numbers, biomass and production of perch have been found to be low compared with perch in England and Europe. Low production of perch in Lochs Kinord and Davan is due to cannibalism of larval perch, and a combination of intense predation by adult perch and pike on juveniles. In lochs where pike were not present, production was similarily low and was regulated by cannibalism. Low biomass produces good growth rates and consequently, in the case of perch in simple fish systems, a short lifespan. As year class strength does not fluctuate greatly, biomass of adults (>3 years old) is stable from year to year. Although perch is not a main species for anglers in Scotland, the perch fishery is likely to expand slightly in the coming years, although unlikely ever to displace interest in salmonids. There has been intermittent discussion about the creation of a commercial fishery for coarse fishes including pike, eels and perch in the highlands. This has met local opposition from salmonid anglers as salmonids could not be avoided as a bye catch, as the fishery for these coarse species could

Figure 6 A comparison of the numbers and biomass of pike (>2 years) and perch (>3 years) in Lochs Kinord and Davan

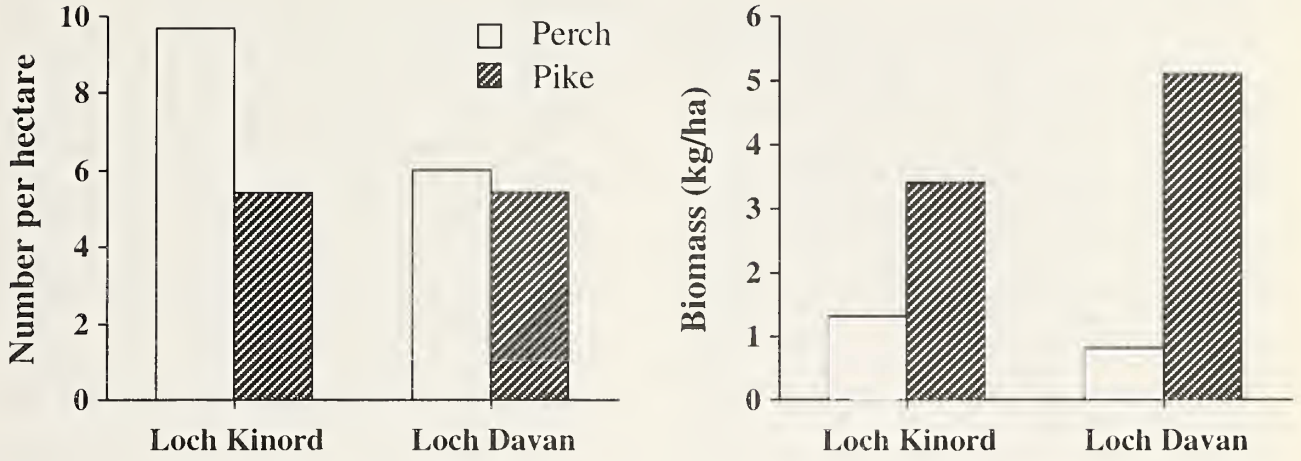
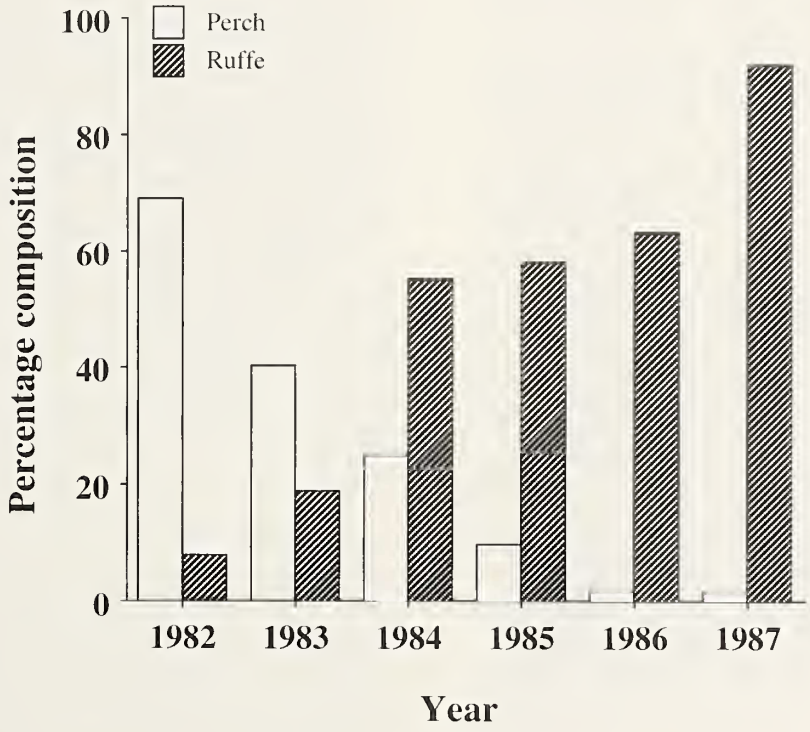


Figure 7. Percentage composition of annual catch on the water intake screens at Loch Lomond.
Data from Maitland and East, 1989.



become depleted quickly and there is therefore no sign of a fishery developing (Ian Sutherland, pers. comm.). Acidification has not affected perch in Scotland as they are distributed mainly in lowland buffered waters. Perch in Scotland have been affected favourably by eutrophication with a moderate improvement in growth and consequently increased biomass and production (Treasurer, 1990b). The possible expansion of ruffe to other catchment areas in Scotland is likely to be a potential threat to indigenous fishes. Therefore the status of ruffe in Loch Lomond should be monitored and any expansion in range studied.

REFERENCES

Adams, C.E. & Tippett, R. (1991). Powan ova (*Coregonus lavaretus* (L.)) predation by newly introduced ruffe (*Gymnocephalus cernuus* (L.)) in Loch Lomond, Scotland. *Aquaculture and Fisheries Management* 22, 239-246.

Ali, S.S. (1973). The perch *Perca fluviatilis* L. and the roach *Rutilus rutilus* L. of Llyn Tegid, North Wales. Ph.D. thesis, University of Liverpool.

Campbell, R.N. (1955). Food and feeding habits of brown trout, perch and other fish in Loch Tummel. *Scottish Naturalist* 67, 23-27.

Craig, J.F. (1974). Population dynamics of perch, *Perca fluviatilis* L. in Slapton Ley, Devon. II. Age, growth, length-weight relationships and condition. *Freshwater Biology* 4, 433-444.

Goldspink, C.R. & Goodwin, D. (1979). A note on the age composition, growth rate and food of perch *Perca fluviatilis* (L.) in four eutrophic lakes, England. *Journal of Fish Biology*, 14, 489-505.

Hart, P. (1971). The roach (*Rutilus rutilus* L.) in the River Nene, Northants and its relationship to four other fish species. *Proceedings of the 5th British Coarse Fish Conference,* pp. 138-145. University of Liverpool.

Hartley, P.H.T. (1947). The natural history of some British freshwater fishes. *Proceedings of the Zoological Society of London* 117, 129-206.

Jones, D.H. (1982). The spawning of perch (*Perca fluviatilis* L.) in Loch Leven, Kinross, Scotland. *Fisheries Management* 13, 139-151.

Kipling, C. (1976). Year class strengths of perch and pike in Windermere. *Report of the Freshwater Biological Association* 44, 68-75.

Le Cren, E.D. (1958). Observations on the growth of perch (*Perca fluviatilis* L.) over twenty-two years with special reference to the effects of temperature and changes in population density. *Journal of Animal Ecology* 27, 287-334.

Le Cren, E.D., Kipling, C. & McCormack, J.C. (1977). A study of the numbers, biomass and year-class strengths of perch (*Perca fluviatilis* L.) in Windermere from 1941 to 1966. *Journal of Animal Ecology* 46, 281-307.

Maitland, P.S. (1972). A key to the freshwater fishes of the British Isles. *Scientific Publication of the Freshwater Biological Association* 27, 1-137.

Maitland, P.S. (1977). Freshwater fish in Scotland in the 18th, 19th and 20th centuries. *Biological Conservation* 12, 265-277.

Maitland, P.S. & Campbell, R.N. (1992). *The Freshwater Fishes of the British Isles.* Harper Collins, London.

Maitland, P.S. & East, K. (1989). An increase in the numbers of ruffe, *Gymnocephalus cernua* (L.), in a Scottish loch from 1982 to 1987. *Aquaculture and Fisheries Management* 20, 227-228.

Maitland, P.S., East, K. & Morris, K.H. (1983). Ruffe *Gymnocephalus cernua* (L.), new to Scotland, in Loch Lomond. *Scottish Naturalist* 1983, 7-9.

Mann, R.H.K. (1978). Observations on the biology of the perch, *Perca fluviatilis,* in the River Stour, Dorset. *Freshwater Biology* 8, 229-239.

McCormack, J.C. (1965). Observations on the perch population of Ullswater. *Journal of Animal Ecology* 34, 463-478.

Menshutkin, V.V. & Zhakov, L.A. (1964). Mathematical determination of the nature of the population dynamics of perch in given ecological conditions. In: *Ozera Karel; skogo Peresheika limnolgiya i Metodika Issledovanii.* pp. 140-145. Moscow: Nauka (in Russian).

Oliva, O. & Holcik, J. (1965). The estimation of the fish population in the Klicava valley water reservoir. *Vestnik Ceskoslovenske Spolecnosti Zoologicke* 29, 249-254.

Rosch, R. & Schmid, W. (1997). Ruffe, newly introduced into Lake Constance: preliminary data on population biology and possible effects on white fish (*Coregonus lavaretus* L.) *Annales Zoologici Fennici* 33, 467-71.

Savino, J.F. & Kolar, C.S. (1996). Competition between nonindigenous ruffe and native yellow perch in laboratory studies. *Transactions of the American Fisheries Society* 125, 562-571.

Shafi, M. (1969). Comparative studies of populations of perch (*Perca fluviatilis* L.) and pike (*Esox lucius* L.) in two Scottish lochs. Ph.D. Thesis, University of Glasgow, Glasgow.

Shafi, M. & Maitland, P.S. (1971). The age and growth of perch (*Perca fluviatilis* L.) in two Scottish lochs. *Journal of Fish Biology* 3, 39-57.

Thorpe, J.E. (1974). Trout and perch populations at Loch Leven, Kinross. *Proceedings of the Royal Society of Edinburgh* B 74, 295-313.

Thorpe, J.E. (1977a). Daily ration of adult perch, *Perca fluviatilis* L., during summer in Loch Leven, Scotland. *Journal of Fish Biology* 11, 55-68.

Thorpe, J.E. (1977b). Synopsis of biological data on the perch, *Perca fluviatilis* Linnaeus 1758, and Perca flavescens Mitchill 1814. *FAO Fisheries Synopses* 113. 138 pp.

Treasurer, J.W. (1980). The reproductive biology and early life history of perch, *Perca fluviatilis* L., in two Aberdeenshire lochs. Ph.D. thesis, University of Aberdeen.

Treasurer, J.W. (1981). Some aspects of the reproductive biology of perch, *Perca fluviatilis* L. Fecundity, maturation and spawning behaviour. *Journal of Fish Biology* 18, 729-740.

Treasurer, J.W. (1983). Estimates of egg and viable embryo production in a lacustrine perch. *Environmental Biology of Fishes* 8, 3-16.

Treasurer, J.W. (1988). The distribution and growth of lacustrine 0+ perch, *Perca fluviatilis. Environmental Biology of Fishes* 21, 37-44.

Treasurer, J.W. (1989). Mortality and production of 0+ perch, *Perca fluviatilis* L., in two Scottish lakes. *Journal of Fish Biology* 34, 913-928.

Treasurer, J.W. (1990a). The food and daily food consumption of lacustrine 0+ perch, *Perca fluviatilis* L. *Freshwater Biology* 24, 361-374.

Treasurer, J.W. (1990b). The responses of pike *Esox lucius* L., and perch, *Perca fluviatilis* L. to nutrient enrichment in three Deeside lochs, Scotland. M. Phil. thesis, Open University.

Treasurer, J.W. (1992). The predator-prey relationship of perch, *Perca fluviatilis,* larvae and zooplankton in two Scottish lochs. *Environmental Biology of Fishes* 35, 63-74.

Treasurer, J.W. (1993). The population biology of perch, *Perca fluviatilis* L., in simple fish communities with no top piscivore. *Ecology of Freshwater Fish* 2, 16-22.

Treasurer, J.W. & Holliday, F.G.T. (1981). Some aspects of the reproductive biology of perch *Perca fluviatilis* L. A histological description of the reproductive cycle. *Journal of Fish Biology* 18, 359-376.

Treasurer, J.W., Owen, R. & Bowers, E. (1992). The population dynamics of pike, *Esox lucius,* and perch, *Perca fluviatilis,* in a simple predator-prey system. *Environmental Biology of Fishes* 34, 65-78.

Williams, W.P. (1965). The population density of four species of freshwater fish, roach (*Rutilus rutilus* (L.)), bleak (*Alburnus alburnus* (L.)), dace (*Leuciscus leuciscus* (L.)) and perch (*Perca fluviatilis* (L.)), in the River Thames at Reading. *Journal of Animal Ecology* 34, 173-185.

Williams, W.P. (1967). The growth and mortality of four species of fish in the River Thames at Reading. *Journal of Animal Ecology* 36, 695-720.

Winfield, I.J., Adams, C.E. & Fletcher, J.M. (1997). Recent introductions of the ruffe *Gymnocephalus cernuus* to three United Kingdom lakes containing *Coregonus* species. *Annales Zoologici Fennici* 33, 459-66.